MODEL E8 SERIES

GPS Timing & Frequency Standard

USER'S HANDBOOK

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Safety Considerations

General

This product and related documentation must be reviewed for familiarisation before operation. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the instrument may be impaired.

Before Applying Power

Verify that the product is set to match the available line voltage and the correct fuse is installed.

Before Cleaning

Disconnect the product from operating power before cleaning.

WARNING

Bodily injury or death may result from failure to heed a warning. Do not proceed beyond a warning until the indicated conditions are fully understood and met.

CAUTION

Damage to equipment, or incorrect measurement data, may result from failure to heed a caution. Do not proceed beyond a caution until the indicated conditions are fully understood and met.

This equipment must be earthed

An uninterruptible safety earth ground must be maintained from the mains power source to the product's ground circuitry.

WARNING

When measuring power line signals, be extremely careful and use a step down isolation transformer whose output is compatible with the input measurement capabilities of this product. The product's front and rear panels are typically at earth ground. Thus, never try to measure AC power line signals without an isolation transformer.

WARNING

Instructions for adjustments when covers are removed and for servicing are for use by service-trained personnel only. To avoid dangerous electrical shock, do not perform such adjustments or servicing unless qualified to do so.

WARNING

Any interruption of the protective grounding conductor (inside or outside the instrument) or disconnecting of the protective earth terminal will cause a potential shock hazard that could result in personal injury. Grounding one conductor of a two conductor out-let is not sufficient protection.

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

If the instrument is to be energised via an autotransformer (for voltage reduction) makes sure the common terminal is connected to the earthed pole terminal (neutral) of the power source.

Instructions for adjustments while the covers are removed and for servicing are for use by service-trained personnel only. To avoid dangerous electrical shock, do not perform such adjustments or servicing unless qualified to do so.

For continued protections against fire, replace the line fuse(s) with fuses of the same current rating and type (for example, normal blow time delay). Do not use repaired fuses of short-circuited fuse holders.

Voltage, Frequency and Power Characteristics

AC Power Adaptor

Voltage 100-240V AC

Frequency 40-50Hz

Power characteristics 500mA Max

Voltage 12V dc 300mA – 500mA

Environmental Conditions

Temperature

Operating (ambient)	-10°C to +55°C (-65 to +65 op)
Storage	-40°C to +85°C

Magnetic Field

Sensitivity	$\leq 2x10^{-11}$/ Gauss
Atmospheric Pressure	-60m to 4000m
	$<1x10^{-13}$/ mbar

Replaceable Fusing Characteristics

N/A

Cleaning Instructions

To ensure long and trouble operation, keep the unit free from dust and use care with liquids around the unit.

Be careful not to spill liquids onto the unit. If the unit does get wet, turn the power off immediately and let the unit dry completely before turning it on again.

Clean with a damp (with water) cloth.

Never spray cleaner directly onto the unit or let liquid run into any part of it. Never use harsh or caustic products to clean the unit.

E8 Series GPS Timing & Frequency Reference

Introduction

The GPS clock is shipped ready for operation. No adjustments are needed to have a 10MHz frequency reference and 1 pulse per second time reference within 20 minutes of initial switch on.

The status of the GPS lock is shown on four LEDs on the front panel.

For more information as to satellite signal strengths, etc, a computer with RS232 may be connected to the interface. A freeware program such as WinOncore may be used to display information from the GPS receiver.

Installation

The antenna should be installed, preferably with a 360 degree view of the sky. However the receiver is very sensitive and will give good results with the antenna on a window ledge, or even inside a building. The satellite signal strengths may be checked after installation using a computer with suitable software connected to the RS232 interface. The DC power supply should be connected. The unit will operate with any voltage between 6 and 15V DC. Current consumption for the E8-X is about 250mA max and the E8-Y about 300mA continuous, 500mA maximum warm up. A universal line power supply is provided.

Operation

The unit is fully programmed to operate without adjustment anywhere in the world. The GPS receiver will take about 1 minute to obtain a fix from a cold start with unknown location. The receiver then does a "site survey" for about 15 minutes, averaging the positions obtained. After the site survey is complete, the receiver switches to position hold mode, and uses all the satellites available to improve the accuracy of the time calculation. At this point the unit will lock its 20MHz reference oscillator to the GPS signal. This only takes a few seconds. When the PLL locks the red "lock" LED should go out, but may flash for a further minute as the PLL settles. The normal operating condition is with the red "lock" LED off.

The status of the satellite tracking is shown by the green and amber LEDs. The normal situation is that the green LED shows a long flash, followed by a number of short flashes. The number of short flashes shows the number of satellites being tracked, and included in the time solution. The amber LED may also flash. This shows the number of satellites being tracked, but not included in the timing solution.

If the red "lock" LED should start to flash at about 1Hz rate, this indicates that the phase error between the GPS signal and the internal 20MHz oscillator is greater than a pre programmed threshold. This does not indicate that the 10MHz output is unlocked. During normal operation the GPS receiver estimates the accuracy of the timing solution using the "TRAIM" algorithm (Time Receiver Autonomous Integrity Monitoring) developed for the Motorola Oncore receiver. If the predicted timing error is greater than the programmed limit, the receiver will switch into standby, and the red lock LED will turn on. The 10MHz output and 1pps output will then drift according to the ambient temperature and aging of the internal oscillator. The unit should never go into standby during normal operation. The most likely reason for doing so is a major antenna fault.

Interface and programming

The unit has one RS232 compatible interface. This is shared between the GPS receiver and the microcontroller that locks the 10MHz output to the GPS signal. On Initial switch on the interface is connected to the microcontroller. If no valid interface code is received within 30 seconds, the interface switches over to the GPS receiver. If a valid interface code is received, the interface remains connected to the microcontroller until the next power on reset.

GPS interface

The GPS receiver interface uses Motorola binary format. In order to use this, a freeware program such as WinOncore should be installed on the user's PC.

Connect the unit to the PC and start the program. It may be necessary to set the port and baud rate (9600). The receiver is preset to output 3 sentences on a continuous basis. These are Ha, (position/status/data), Hn, (12 channel TRAIM status message) and Bb (Visible satellites).

The various windows available from the program should show current satellite data, etc.

It is important to note that some parameters shown by the program will not correctly indicate the actual state of the receiver. This is because the program does not automatically update its information when started. In particular, the TRAIM algorithm will be shown as off when in fact it is by default on in the receiver.

For the receiver to operate correctly, the site survey must be enabled, and the TRAIM must be on. If this is not the case, the receiver will track satellites and compute a fix, but the red lock LED will not go out, showing the 10MHz output is in the standby state.

If the receiver gets stuck in a state where it does not lock, the user may inadvertently disabled the TRAIM or the site survey. To get back to a known state, the following should be performed:

The messages can be sent using the message window in the WinOncore software.

Return to factory default state:

"@@Cf"

Enable Position Auto-survey; consult the CW12 user manual for further details

"@@Gd03"

Enable T-RAIM algorithm; consult the CW12 user manual for further details.

- "@@Ge01"

Set the alarm threshold for the T-RAIM algorithm (300ns). See the CW12 user manual for further details

"@@Gf0003"

Request channel T-RAIM status message (sent every second)

"@@Hn01"

If required, the position/status/data message may be turned on:

"@@Ha01"

If required, the visible satellites message may be switched on:

"@@Bb01"

The GPS receiver stores the current status in non volatile memory when switched off.

Microcontroller Interface

The microcontroller interface allows setup and debug of the digital phase lock loop which locks the 20MHz reference oscillator to the GPS receiver. The list of control codes is given in an appendix.

The only user adjustable parameter is the PLL bandwidth, which is accessed with command "UA". The band width has been factory set to optimum for the E8-X (TCXO) and the E8-Y (OCXO). It is only recommended that the user adjusts these values if he is able to measure Allen variance of the 10MHz output at averaging times between 1 and 1000 seconds.

"UA?" will return the current bandwidth (0 to 7, with 0 the narrowest bandwidth)

The second parameter (hex) is the elapsed running time in units of 2.33 hours.

GPS and Windows Serial Mouse Issue

Problem: It is possible for windows to incorrectly interpret the data output from the Quartzlock GPS interface as the output of a Microsoft Serial BallPoint Mouse. When that happens, Windows loads drivers for the Serial BallPoint Mouse. This causes the cursor to move erratically about the display, clicking, right clicking, double clicking, dragging and dropping display items as it goes. On Windows 2000, XP and Vista, you may not experience the problem if you wait until after the computer is booted before connecting the Quartzlock GPS to the serial communications port. This problem is not specific to Quartzlock GPS. Any NMEA/Binary output device connected to a Windows computer's serial port is likely to cause this problem. Below are several possible solutions to this problem.

Solution 1.

The easiest solution is to disable the Serial BallPoint mouse in the Device Manager. Of course, this solution assumes that you do not need to use a Serial BallPoint mouse with your computer. When the wild mouse problem occurs follow the steps below.

1. Unplug the DB9 connector.
2. Right click the **My Computer** icon on your desktop and select **Properties** to open the Device Manager.
3. Go to the hardware tab of the resulting pop up window and click on the **Device Manager** button.
4. Right click on **Serial BallPoint Mouse** and choose the option to **Disable** (NOT uninstall) this device.

Solution 2:

Do not plug the DB9 connector into the computer until the computer is turned on and the operating system is completely booted and running. Every time you use the Quartzlock GPS, you will need to start the computer and operating system before making the connection between the Quartzlock GPS and the computer. This solution normally works on Windows 2000, XP and Vista computers.

Specifications

OUTPUTS:

Sine wave, 10MHz, 12dBm ± 2dBm into 50ohms

Harmonics < -50dBc

Spurii <-75dBc

TTL, 3.3VCMOS, 1pulse per second

POWER SUPPLY:

6 to 15V DC 250mA – 500mA

DPLL tracking bandwidths

5mHz to 500mHz typical in 8 binary increments

Default 20mHz

LOCK INDICATOR

On	not locked
Off	locked, low phase error
Short flash every second:	locked, high phase error

GPS INDICATOR

Green: indicates no of satellites used in time solution

Amber: indicates no of satellites tracked but not used in time solution

INTERFACE

Shared between DPLL and GPS receiver

DPLL	9.6kbaud, RS232, PC compatible	(8bits no parity, no handshake)
GPS	9.6kbaud, Motorola binary format	

INTERFACE CODES

See Appendix B

TIME DOMAIN STABILITY

(10MHz output)

Tau	Allen variance
	E8-X
1s	$<2x10^{-10}$
10s	$<4x10^{-10}$
100s	$<5x10^{-11}$
1000s	$<1x10^{-11}$
>10000s	$<5x10^{-12}$

JITTER

(1PPS output)

Typical < 5ns RMS

Phase Noise

	E8-X
1Hz	-60dBc
10Hz	-90dBc
100Hz	-115dBc
1 kHz	-130dBc
10 kHz	-140dBc

WARMUP

< 15 minutes to specified accuracy

Appendix A

Board set up

Links

SP1 Leave open circuit, Used to upload new firmware to the CW25 GPS module.

SP2 Leave open circuit for 3.3V antenna power. Link (default) for 5V antenna power.

SP3 Link only when external clock version of the CW25 is used.

SP4 Leave open circuit when U5 (enhanced voltage reference) is used. Link when U5 is not fitted to board.

JP1 & JP3 fit both jumpers with shorting links for normal operation. Links must be removed when programming U3 from the Microchip ICD-2 programmer. U3 should be powered from the programmer when programming. This is necessary as U3 cannot be programmed with 3.3V Vdd.

U5 May be omitted when TCXO reference is used.

U16 MUST be omitted when internal clock version of the CW25 is used. It must be fitted when the external clock version of the CW25 is used.

Appendix B

RS232 control codes

(all values following command or returned from the microcontroller are hexadecimal)

* = backed up in EEPROM

UA User adjust

UA? Returns user parameters aa bbbb

* aa is bandwidth control: bits set: bit0, 1, 2: bandwidth (0 to 7)

* bbbb is clock registers 3 and 4 (elapsed time)

UABaa Write new bandwidth control byte

OS Overall Status

OS? Returns overall status bytes: aa bb cccc

aa is test status byte:

Bits set: bit0, 1, 2:		bits 0 to 2 DAC output select
	bit3:	no integrator update
	bit4:	no proportional term
	bit5:	Inhibit holdover mode
	bit6:	NU
	bit7:	inhibit state control
Bits 2, 1, 0:	000	no test output, fine tune DAC used for tuning
	001	sub sampled I
	010	sub sampled Q
	011	PLL Integrator upper 16 bits
	100	Phase result
	101	I sample (filtered)
	110	Q sample (filtered)
	111	references CH6 (filtered)

bb is lock status byte:

Bits set	bit0 to 2:	State control, states 0 to 7
	bit3:	set to normalise tuning DACs (cleared automatically)
	bit4:	NU
	bit5:	Loop locked
	bit6:	narrow range phase detector in use
	bit7:	set to inhibit auto load of PLL gain parameters

cccc is PLL control:

Bits set	bit0, 1, 2, 3	subsample rate
	bit4, 5, 6, 7	exp filter order
	bit8, 9, 10, 11	integrator gain
	bit12, 13, 14, 15	proportional gain

OSTaa Write new test status byte

OSLbb Write new lock status byte

OSGcccc Write new PLL control

PL Phase lock loop

PL? Returns current status of PLL

aaaa bbbb cccccccc dddd eeee

	aaaa	last value of I sample (filtered), 2s complement, 16 bit
	bbbb	last value of Q sample (filtered), 2s complement 16 bit
*	cccccccc	last value of PLL integrator (32 bit integer)
	dddd	Coarse tune DAC 16 bit integer
	eeee	Fine tune DAC 16 bit integer

PLIcccccccc Write new PLL integrator

PLCdddd Write new coarse tune DAC

PLFeeee Write new fine tune DAC

PL+ Enter command PL? into repeat stack

PD Phase detector

PD? Returns phase detector parameters

aaaa bbbb cccc dddd eeee

aaaa	Last phase result, 2s complement
bbbb	Last mod[I] +mod[Q]
cccc	2.5V reference (filtered)
dddd	mod (phase result) (filtered) lsb=3.05ps
eeee	mod(freq offset) (filtered) lsb = 2.33E-14

PD+ Write PD? to command repeat stack

EU EEPROM

Update (backed up values)

SR Software Reset

ER EEPROM read

ERCaabb Returns bb bytes from starting address aa as ASCII characters

ERNaabb Returns bb bytes from starting address aa as hexadecimal numbers (character pairs)

EW EEPROM write

EWCaabbccccc------c

Writes bb characters to starting address aa. Correct number of characters must be included in string

EWNaabbcccc------c

Writes bb bytes to starting address aa. Character pairs cc etc. are interpreted as hexadecimal numbers.

RI Repeat Interval

RI? Returns command repeat interval

aa

aa	8 bit command repeat interval multiplier. Range 1 to 255. Command repeat interval is 50ms x aa

RI0aa Write new command repeat interval

RID Cancel command repeat and clear command repeat stack